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(71) Applicant: JUNO ENTERPRISES, INC. [US/US]; 11490 Xeon Street, Coon Rapids, MN 55448 (US).

(72) Inventors: MISSO, Nigel, F.; 5714 Silas Dent Road Northwest, Rochester, MN 55901 (US). ORGON, Richard, A.; 20610 Cottonwood Street, Cedar, MN 55011 (US). VALLEY, Steven, P.; 5891 Hamline Avenue North, Shoreview, MN 55126 (US).

(74) Agents: ANGUS, Robert, M. et al.; Kinney & Lange, P.A., Suite 1500, 625 4th Avenue South, Minneapolis, MN 55415-1659 (US).

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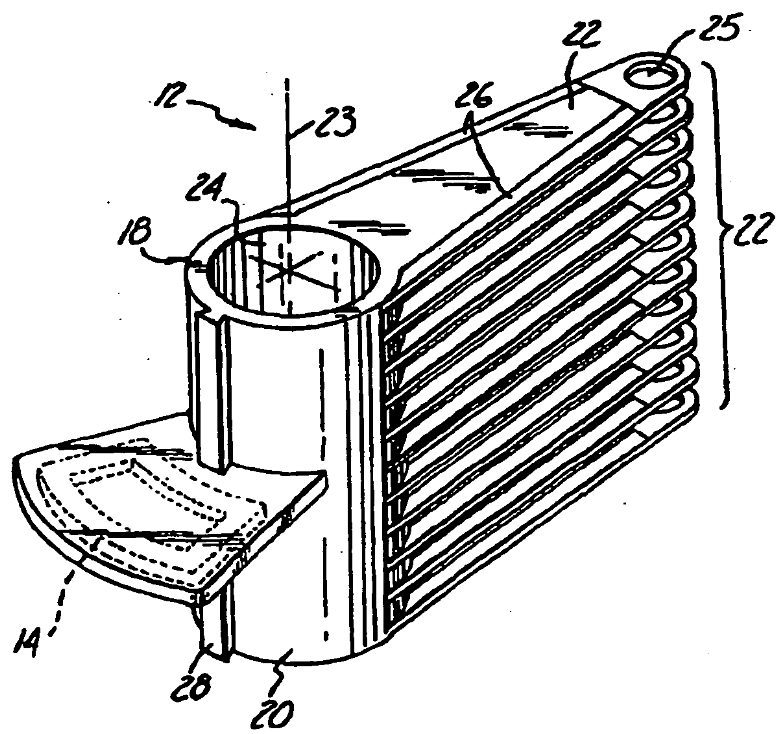
(54) Title: INJECTION MOLDED E-BLOCK

(57) Abstract

An injection molded E-block assembly (12) for a disk system (2) for supporting a plurality of head arrays (10) to write data to and/or retrieve data from tracks of a media disk (6). The E-block assembly is formed of a polymeric material that matches the performance of currently used materials, and the injection mold process eliminates or reduces machining required to produce a finished component.



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INJECTION MOLDED E-BLOCK

BACKGROUND OF THE INVENTION

The present invention relates to an E-block assembly in a disk drive system. More specifically, the present invention relates to an E-block assembly formed of an injection molded polymer.

Hard disk drives (HDDs) are the data and program storage medium of choice for most of the computers used in the world today. A hard disk drive consists of an enclosure called the head-disk assembly (HDA), electronics, and means to mount the hard disk drive in the using system. The head-disk assembly includes a spindle with at least one media disk (magnetic or optical) on which data is stored in concentric tracks by means of data head assemblies which write and/or read coded data. While disk drives and the accompanying head-disk assemblies may use either magnetic or optical systems to record data, this application will discuss the present invention in the context of a magnetic disk drive. Of course, it is to be understood that many of the concepts discussed herein are equally applicable to an optical disk drive system.

In a magnetic disk drive, one or more magnetic disks are mounted on a spindle which rotates the disk(s) at high speed while a magnetic read/write head (carried by a slider) "flies" over the surface of the rotating disk at an extremely small height (measurable in microns). As the disk rotates, the aerodynamic properties of the slider allow the head assembly to glide over the disk on a cushion of air. The head assemblies are flexibly attached to a rigid support arm which is part of an actuator that selectively locates the head assemblies over the disk surfaces.

There are two basic types of actuators: linear and rotary. A linear actuator positions the head assembly linearly along a radius of the disk. A rotary actuator, used in the vast majority of disk drives today, functions much like the tone-arm on a record player, with the actuator

positioning the head assembly along an arc over the disk surface. A rotary actuator consists of several components: an E-block assembly, one or more head assemblies, and a flexible circuit to carry power and signals to and from the head assemblies. The E-block assembly includes an E-block, an actuator coil, a bore or other means for locating a bearing cartridge for allowing rotary movement of the E-block assembly, and means to attach and locate the required flexible circuitry. The focus of this invention is on the component referred to as an E-block assembly. Specifically, the invention relates to the construction and method of manufacture of E-block assemblies.

Disk drives and their various components are manufactured and marketed in a world wide market and may be considered commodity products. Thus, as is true for any commodity product, the cost of a disk drive system and its attendant components is a critical parameter in achieving sales of the product. The cost includes factors such as the raw component material, processing (forming, packaging, handling, etc.), recycling of scrap and process wastes, product development, testing, product life, and system performance. Minimizing the cost of a disk drive and its components, such as E-block assemblies, thus encompasses a wide range of design and manufacturing issues.

It is clear that the component's material and the method of producing the component have an effect on cost. Like all manufacturing decisions, the selection of material and method of manufacture requires a tradeoff of costs and advantages to obtain the desired product performance at the lowest cost possible. The parameters for selecting a material and method of manufacture for an E-block assembly in a disk drive can be grouped into three main areas: 1) material and finished product performance, 2) manufacturability, and 3) life expectancy. In most instances, these parameters are optimized to improve the access

performance of the disk drive. For example, power consumption may be minimized for a given access performance, or access performance may be maximized for a given power consumption.

For disk drive systems, it is desired to maximize the E-block assembly stiffness and minimize the system inertia, because increased stiffness and reduced mass result in improved access performance (i.e., faster access time and smaller power requirements). A stiffer system will respond faster, as greater stiffness minimizes "settle" time at the desired location. The faster a system "settles", the faster the head assembly can read or write data on the disk. A low inertia allows an E-block assembly, to be moved quickly from one location to another with a minimum of power consumption.

Several mechanical properties determine the stiffness and inertia of a system. These properties are material density, flexural modulus, and specific flexural modulus. A low material density is desired because a low density allows more material to be used to improve the stiffness of the E-block, while maintaining low mass (and thus low inertia). A low material density can reduce cost by eliminating the need for incorporating weight reducing holes into the product. Including weight reducing holes in an E-block requires additional manufacturing steps (such as machining of the component) which add additional costs. Further, the holes may induce air turbulence which effects the performance of the head assemblies as they "fly" over the surface of the disk.

A high flexural modules (lbs/in^2 or Pa), when combined with a low density (lbs/in^3 or kg/m^3), produces a higher specific flexural modules (in or m^2/s^2). Specific flexural modules is related to the resonance frequency of a structure of a given size and shape, with a high specific flexural modules indicating a high resonance frequency of the structure. A higher resonance frequency results in improved access performance of the E-block because the assembly may be moved faster without inducing

resonance of the assembly. Resonance, or vibration of the assembly, increases "settle" time which, as discussed above, increases the time required before the head assemblies can read or write data to the disks.

Thermal stability of the E-block is also important in the performance of the disk drive system. As the temperature of a material changes, the material undergoes thermal distortion. In the case of an E-block, thermal distortion causes the arms of the E-block to move relative to a fixed reference point. This thermally induced movement affects the disk drive performance by altering the position of the head assemblies such that they may no longer be able to accurately read and write data to the disks. To minimize the effects of thermal distortion, it is preferred that the material causes all the arms to return to their original positions when the thermal stress is removed. Thus, when selecting a material and method of manufacture for an E-block, the thermal stability of the material and affect of the method of manufacture on thermal distortion are important considerations.

In addition to selecting a material which optimizes the system performance, it is also desired that the component be easy to produce and have a life expectancy at least as long as the life of the assembled product. These three areas (i.e., performance, manufacturability, and life expectancy) each place specific demands on selection of material and method of manufacture. As noted above, to optimize the E-block assembly performance, the material properties relating to density, flexural modules, specific flexural modules, and thermal stability are important. For ease of manufacture, material properties such as ultimate strength, yield strength and tensile modules are important, as well as the ability to assemble, bond, and machine the material. The life of the component is effected by the material's corrosion resistance and need for surface treatment, and in the

case of an E-block assembly, the material's electrical conductivity. The importance of each of these factors is explained below.

An E-block assembly undergoes a significant amount of handling and transport during the manufacturing process. The component must be sufficiently strong to withstand the handling (and possible abuse) to which it is subjected. Therefore, the ultimate strength and yields strength of the material are important. Some materials used to form E-blocks may be functionally damaged in the manufacturing process without the damage being visible. For example, die cast magnesium has a very low yield strength (15×10^3 psi, 103 MPa), with a much higher ultimate strength (32×10^3 psi, 220 MPa). Thus a component made of die cast magnesium may yield (i.e., permanently bend) a slight amount but not break. This is known as plastic deformation. The result of plastic deformation is an unusable component with a defect which may not be detected until late in the manufacturing process, causing a greater manufacturing expense. To avoid this type of damage, a material with a high yield strength and an ultimate strength of essentially the same magnitude is desired. A high yield strength reduces the chance of accidental damage such as plastic deformation, while an ultimate strength close to the yield strength is more likely to produce visual evidence of damage when such deformation occurs. For example, if the yield strength and ultimate strength are equal (i.e., the material is perfectly brittle) any plastic deformation will result in a broken part which is easily detected and discarded early in the manufacturing process. The tensile modulus of the material is important for attaching the head assemblies to the E-block support arms. Head assemblies are often attached by swaging, and it is desired that the E-block assembly material be compatible with the currently used manufacturing processes. For swaging, the material must deflect enough so that the head assembly can be plastically deflected to secure the head assembly to the support arm.

In addition to the above physical properties, it is desired that the material of the E-block assembly be compatible with current adhesive bonding technologies. Many E-block assemblies have wires or other components bonded to the sides of each arm. The E-block assembly material must be chemically compatible with the chosen adhesives to prevent outgassing which may damage the disk drive.

Perhaps most importantly for reduced cost, it is preferable to minimize the amount of machining and assembly required to produce a finished E-block assembly. Present production techniques for E-block assemblies (die casting, investment casting, and extrusion) do not allow a metal or ceramic E-block assembly to be fabricated without extensive machining and/or assembly operations. In the current manufacturing processes, a rough shape of an E-block is formed either by casting or extrusion, and machining operations create the finished product. In the case of ceramic materials individual arms are formed which are then machined and assembled into a completed E-block. Machining and assembly adds a large amount to the cost of the product.

The interior of a disk drive is extremely sensitive to foreign materials, such as dust or other particulates. Thus, great care must be taken to ensure such debris is kept out of the disk drive. For metallic E-block assemblies, corrosion products are a significant source of particulates, and some form of surface treatment is required to prevent corrosion of the material. These surface treatments add cost to the finished product, and a product that does not require any special treatment is desirable.

The interior of a disk drive is an electrostatic generator of tremendous potential. When operating, the disks are rotating at a high speed inside a cavity full of dry (non-conducting) air. The rotation of the disks causes the air to rotate also, resulting in dry air moving across the actuator at high speeds. If the actuator and disk assembly are not

adequately grounded, an electrostatic charge will build up, eventually dissipating through a circuit of the disk drive. The electrostatic charge may be of a magnitude large enough to destroy the circuit and also the disk drive. To prevent an electrostatic buildup, the material of E-block must be electrically conductive to properly ground the E-block assembly.

A need exists for an E-block assembly capable of meeting or exceeding current performance levels which is easy to manufacture at a low cost. Specifically, there is a need for an E-block assembly that reduces the amount of machining and assembly required for the production of a finished product, while being compatible with currently used production methods.

SUMMARY OF THE INVENTION

The present invention is an injection molded E-block assembly made of a high modulus carbon fiber material. The polymer material has a low density, yet achieves a specific flexural modulus higher than the most commonly used metals (aluminum and magnesium). The polymeric material has a yield strength similar to aluminum and magnesium with an ultimate strength nearly equal to its yield strength, producing a nearly perfectly brittle material. Components subject to excessive (damaging) forces are thus easily detected by visual inspection, because such excessive forces will result in a broken component. A tensile modulus similar to currently used metals allows the use of known swaging operations for the connection of head assemblies to the E-block support arms. By using a polymeric material which is electrically conductive to form a unitary E-block, the arms of the E-block may be adequately grounded to prevent the buildup of an electrostatic charge which may damage the disk drive. A polymeric material which is electrically non-conductive is used to encase an actuator coil and rigidly attach the coil to the unitary E-block.

The injection molding process produces an unitary E-block that is compatible with today's requirements for disk drive actuators at a

substantially lower cost. The component is molded to finished product tolerances, and the need for machining the E-block to finished dimensions is greatly reduced or eliminated altogether. The use of a polymeric material which is less dense then currently used materials reduces the system mass and inertia, and improves system performance. A low density material also permits the use of more material for greater E-block stiffness, and at the same time eliminates the need for incorporating weight reducing holes into the E-block, further simplifying manufacturing by reducing the amount of machining required. If desired, the E-block may include features such as bevels on the E-block arms, thereby reducing the E-block mass while maintaining the high stiffness of the component.

An injection molded E-block made of polymeric material also reduces the problem of particulate contamination of the disk drive. The polymeric material is naturally non-corrosive (i.e. no surface treatment is required) and thus will not generate particulates which may damage the disk drive.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of the head disk assembly of a disk drive system.

FIG. 2 is a perspective view of a unitary E-block with a plurality of support arms.

FIG. 3 is a perspective view of the unitary E-block of FIG. 2 with an actuator coil attached to the unitary E-block.

FIG. 4 is an exploded perspective view of a mold used to form a unitary E-block.

FIG. 5 is a perspective view of the mold of FIG. 4 is its assembled condition.

FIG. 6 is an exploded perspective view of a second injection mold for forming a casing about the actuator coil.

While the above identified drawing features set forth perferred embodiments, this disclosure presents illustrative embodiments of the present invention by way of representation and not limitation. It should be understood that numerous other modifications and embodiments can be devised by those skilled in the art which fall within the scope and spirit of the priciples of this invention. It should be noted that the figures have not been drawn to scale as it has been necessary to enlarge certain portions for clarity.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIG. 1, a disk drive system 2 includes one or more media disks 6, mounted on a disk spindle 8. The media disks 6 hold encoded information which may be written and/or retrieved by head assemblies 10. Head assemblies 10 are positioned over the surfaces of media disks 6 by an E-block assembly 12. The E-block assembly 12 is capable of supporting a plurality of head assemblies 10 over the media disks 6 of the disk drive system 2 to write data to and/or retrieve data from tracks of the media disks 6. Referring to FIGS. 2 and 3, the E-block assembly 12 includes an actuator coil 14 (shown in broken lines) encased in an injection molded casing 16, and a unitary E-block 18. The unitary E-block 18 has an elongated body portion 20 and a plurality of support arms 22 extending from the body portion 20. The support arms 22 extend from the body portion 20 normal to an axis 23 of the body portion 20, with each arm 22 being capable of supporting at least one head assembly 10. The plurality of support arms 22 each include an attachment hole 25 for attaching the head assemblies 10 to support arms 22. The support arms 22 also include bevels 26 along the edges of the support arms for the purpose of weight reduction of the E-block assembly 12. Alternately, bevels 26 could be replaced by, or used in conjunction with, weight reducing holes (not shown) designed into the support arms 22. The body portion 20 includes along its axis 23 a central

bore 24 for the placement of a spindle 27 for rotation of the E-block assembly 12.

The E-block body portion 20 includes an anchoring means 28. The anchoring means 28 is a tenon used to secure the actuator coil 14 and its surrounding casing 16 to the body portion 20 of the unitary E-block 18. Although described as a tenon, the anchoring means 28 may be of any shape or design which securely and rigidly anchors the actuator coil 14 and accompanying casing 16 to the E-block 18.

METHOD OF MANUFACTURE

The E-block assembly 12 described above is manufactured in an injection mold process. Referring to FIG. 4, a first injection mold 40 is created with a hollow portion 41 shaped to form the E-block assembly 12 described above, with the plurality of support arms 22 disposed axially along the elongated body portion 20 of the E-block 18, and the anchoring means 28 disposed along the body portion 20.

The first injection mold 40 includes a plurality of holes ("pin gates") 42. The pin gates 42 are positioned such that material is injected through the pin gates 42 and into the hollow portion 41 of the injection mold 40. Preferably, the pin gates 42 enter the hollow portion 41 of the injection mold 40 adjacent the portion of the mold 40 which forms the anchoring means 28. Because the surface finish and dimensional tolerances of the anchoring means 28 are not critical to performance of the E-block assembly 12, slight variations or imperfections in that area of the E-block are acceptable.

Preferably, the pin gates 42 are disposed axially along the E-block body 20 opposite the support arms 22. By positioning the pin gates 42 opposite the support arms 22, a uniform and even flow of material occurs around the bore 24 of the block 20 and into the support arms 22. By providing a plurality of pin gates 42 along the E-block body 20 for example,

one pin gate for each support arm, a uniform and synchronous flow of material to each arm is ensured. Forming the arms 22 simultaneously by providing a plurality of pin gate 42 along the body portion 20 also helps reduce any thermal distortion which may be caused if the first injection mold 40 used a nonsymmetrical injection of material into the mold 40. The plurality of pin gates 42 may alternately be positioned adjacent the ends of arms 22, opposite the E-block body 20, to obtain synchronous and symmetrical injection of material into the mold 40.

Before filling the first mold 40, the mold 40 is assembled, as seen in FIG. 5. A bore mandrel 43 is inserted into the mold 40 such that the bore mandrel 43 forms the bore 24 of the E-block assembly 12. An arm mandrel 44 is similarly inserted into the assembled mold 40 to form the attachment holes 25 of the support arms 22.

A first polymeric material 34 is provided for injecting into the first mold 40. Preferably, the first polymeric material 34 is a high modulus carbon fiber material such as the polyphenylene sulfide ("PPS") RTP 1391 HM manufactured by RTP Company of Winona, Minnesota. The PPS manufactured by RTP Company has a density of 0.056 lbs/in^3 (1.56 x 10^3 kg/m^3), compared to 0.097 lbs/in^3 (2.70 x 10^3 kg/m^3) for die cast aluminum and 0.065 lbs/in^3 (1.80 x 10^3 kg/m^3) for die cast magnesium. The specific flexural modulus of the PPS is 116 inches (2.87 x 10^{-2} m^2/s^2), as compared to 103 inches (2.55 x 10^{-2}m^2/s^2) for die cast aluminum and 100 inches (2.49 x 10^{-2} m^2/s^2) for die cast magnesium. The preferred carbon fiber PPS has a flexural ultimate strength and flexural yield strength of 44 x 10^3 psi (303 MPa), producing a nearly perfect brittle material. Die cast aluminum and magnesium, however have much lower flexural yield strengths (23 x 10^3 psi and 15 x 10^3 psi, respectively) (158 MPa and 103 MPa, respectively) and flexural ultimate strengths more than twice the flexural yield strengths (47 x 10^3 psi and 32 x 10^3 psi for die cast aluminum and magnesium,

respectively) (324 MPa and 220 MPa, respectively). The tensile modulus (important for swaging operations) is 10×10^6 psi (69 GPa) for the preferred material, which is similar to the aluminum tensile modulus (10×10^6 psi, 69 GPa) and significantly higher than the magnesium tensile modulus (6.5×10^6 psi, 45 GPa). Further, the corrosion resistance of the PPS is excellent as compared to the fair or poor corrosion resistance of aluminum and magnesium. Additionally, the PPS is electrically conductive, for adequately grounding the E-block assembly.

The first polymeric material 34 is injected uniformly through the pin gates 42 into the assembled mold 40 to synchronously form the support arms 22 of the E-block 18. After the first mold 40 is filled with the first polymeric material 34, the material is allowed to cure to its hardened condition. After the material has sufficiently hardened, the mandrels 43 and 44 are removed, the mold 40 is opened, and the unitary E-block 18 is removed from the injection mold 40. The molded E-block 18 should require no machining other than the removal of any excess flashing remaining at the location of the pin gates 42.

Referring to FIG. 6, a second injection mold 46 is provided to create the finished shape of the E-block assembly 12. The second injection mold 46 is shaped to allow the positioning of at least a portion of the previously molded unitary E-block 18 (the portion with the anchoring means 28) and an actuator coil 14 within the second injection mold 46. The actuator coil 14 and the molded unitary E-block 18 are secured within the second mold 46 by means well known in the art, such as pins or the like.

A second polymeric material 36 is provided for injection into the second injection mold 46. The second polymeric material 36 is preferably electrically non-conductive and suitable for injection molding. Examples of such materials are the glass fiber polyphenylene sulfide ("PPS") RTP 1300 series manufactured by RTP Company of Winona, Minnesota.

The composites of the RTP 1300 series containing between 20% and 40% glass fiber exhibit suitable physical properties. It is preferred that the second polymeric material 36 be electrically non-conductive to adequately insulate the actuator coil 14 and prevent it from "shorting out."

The second polymeric material 36 is injected into the second injection mold 46 to produce a casing 16 around the actuator coil 14. As the second polymeric material 36 is injected into the second mold 46, the second material 36 surrounds and encompasses both the actuator 14 and the anchoring means 28 of the unitary E-block 18. As the second material 36 cures to a hardened condition, the casing 16 is securely and rigidly attached to the anchoring means 28 of the unitary E-block 18.

The second injection mold 46 may also be shaped to provide additional elements which may be required for completion of the E-block assembly. For example, means for mounting flexible cables and grounding wires to the E-block assembly 12 may be included in the second mold 46. After the second polymeric material has cured and hardened, the completed E-block assembly 12 is removed from the second injection mold 46. The E-block assembly 12 can then be utilized in a disk drive system as is known in the art.

Although the present invention has been described with reference to preferred embodiments, workers skilled in the art will recognize that changes may be made in form and detail without departing from the spirit and scope of the invention.

WHAT IS CLAIMED IS:

1. An E-block assembly for supporting a plurality of head assemblies of a disk drive system to write data to and/or retrieve data from tracks of a media disk, the E-block assembly comprising:

an actuator coil;

a casing injection molded around the coil, the casing being formed of an electrically non-conductive polymeric material; and;

a unitary E-block rigidly mounted to the casing and constructed of an electrically conductive polymeric material, the E-block having a pivoting portion having an axis and a plurality of arms extending from the pivoting portion normal to the axis, each arm being capable of supporting at least one head assembly at a free end thereof, the arms being uniformly constructed by simultaneous formation in an injection mold process.

2. A method of producing an E-block assembly for a disk drive system for supporting a plurality of head arrays to write data to and/or retrieve data from tracks of a media disk, the E-block assembly comprising a unitary E-block and an actuator coil, including the steps of:

providing a first injection mold shaped to form a unitary E-block, the unitary E-block comprising a plurality of track accessing arms each with a first end and a second end, each second end being capable of being attached to at least one head assembly, the first ends of the plurality of arms being disposed axially along an elongated central portion of the unitary E-block which defines an axis of rotation of the E-block assembly, the

track accessing arms extending radially from a side of the elongated central portion, and an anchoring means protruding from a side of the elongated central portion;

providing an electrically conductive first polymeric material suitable for injection molding;

injecting the electrically conductive first polymeric material into the first injection mold to fill the mold;

curing the material in the first injection mold;

removing the cured unitary E-block from the first injection mold;

providing a second injection mold shaped to position at least a portion of the molded and cured unitary E-block and the actuator coil within the second injection mold;

providing an electrically nonconductive second polymeric material suitable for injection molding;

positioning at least a portion of the unitary E-block and the actuator coil within the second injection mold;

injecting the electrically nonconductive second polymeric material into the second injection mold to fill the mold and secure at least the portion of the unitary E-block and the actuator coil within the mold as a single unit;

curing the material in the second injection mold;

removing the cured E-block assembly from the second injection mold.

3. The method of claim 2, wherein the portion of the previously molded E-block positioned within the second injection mold includes the anchoring means of the unitary E-block, the anchoring means securing the previously molded E-block to the cured polymeric material injected into the second injection mold of the E-block assembly.

4. The method of claim 2, wherein the anchoring means is a tenon extending axially along a side of the elongated central portion.

5. The method of claim 2, wherein the first injection mold contains gating for injection of the first polymeric material along a side of the elongated central portion, the gating arranged to create a symmetrical and uniform flow of material to each of the accessing arms to simultaneously form the arms and minimize subsequent thermal distortion.

6. The method of claim 5, wherein a plurality of gates corresponding to the number of accessing arms are disposed along the central portion opposite the radially extending accessing arms to cause a uniform flow of material to each of the arms.

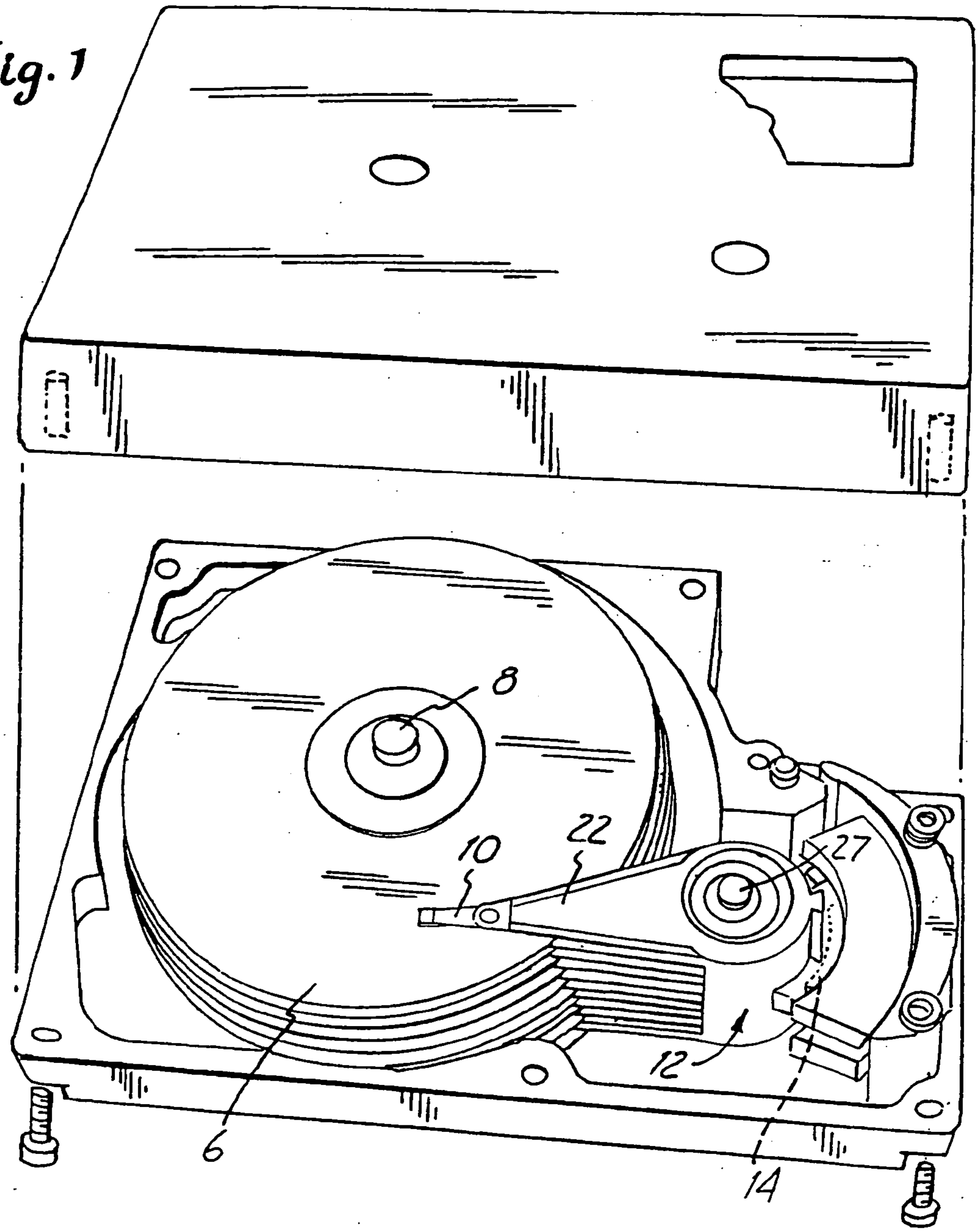
7. The method of claim 5, wherein the anchoring means contains the gating of the first injection mold.

8. The method of claim 7, wherein to cause a uniform flow of material to each of the arms, a plurality of pin gates are disposed along the elongated central portion of the unitary E-block.

9. The method of claim 2, including the insertion of at least one cylindrical mandrel into the first injection mold prior to injecting the first polymeric material, the mandrel creating an attachment hole adjacent each of the second ends of the track accessing arms for attaching at least one head assembly to each of the track accessing arms.

10. The method of claim 2, wherein a cylindrical mandrel is inserted into the first injection mold prior to injecting the first polymeric material, the mandrel axially aligned with the axis of rotation of the E-block assembly to create a spindle hole for mounting the E-block assembly in the disk drive system.

Fig. 1



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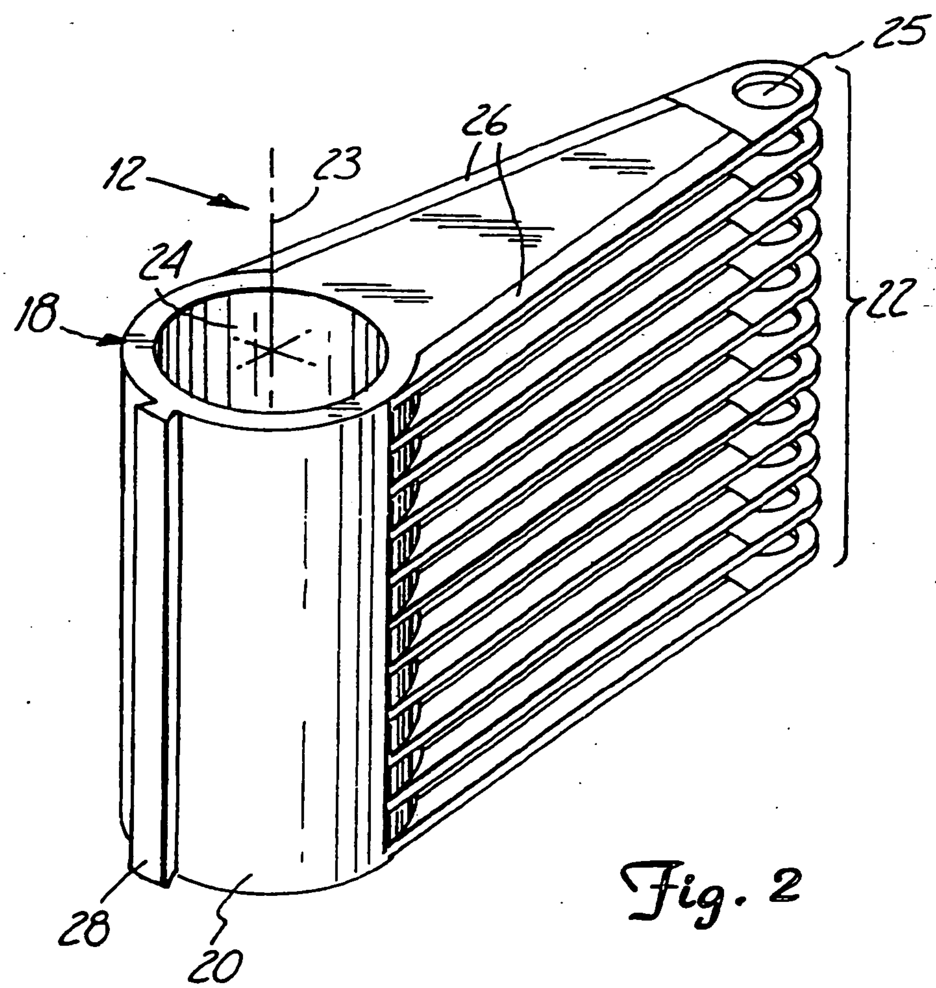

Fig. 2

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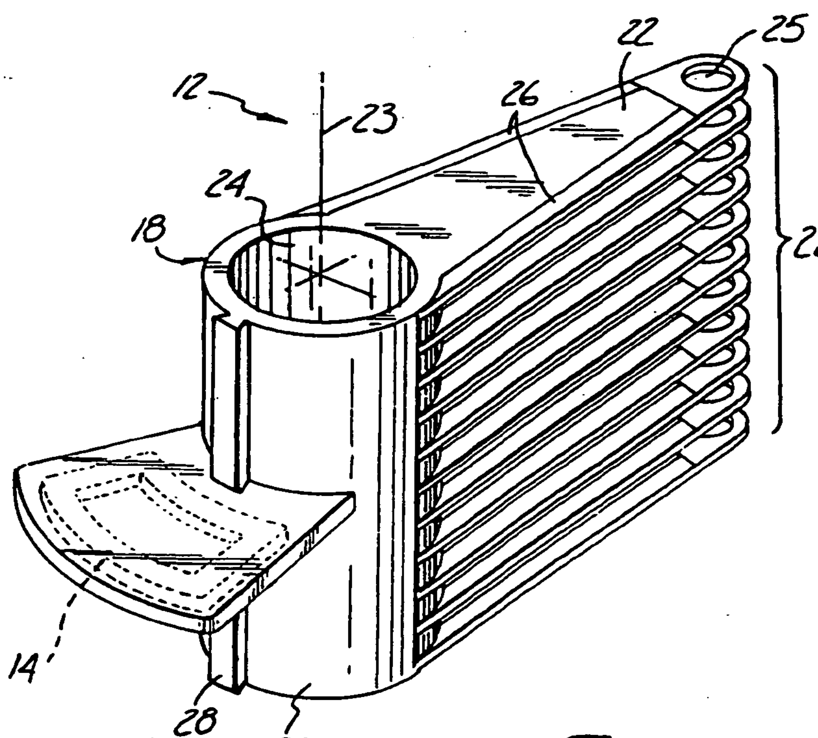

Fig. 3

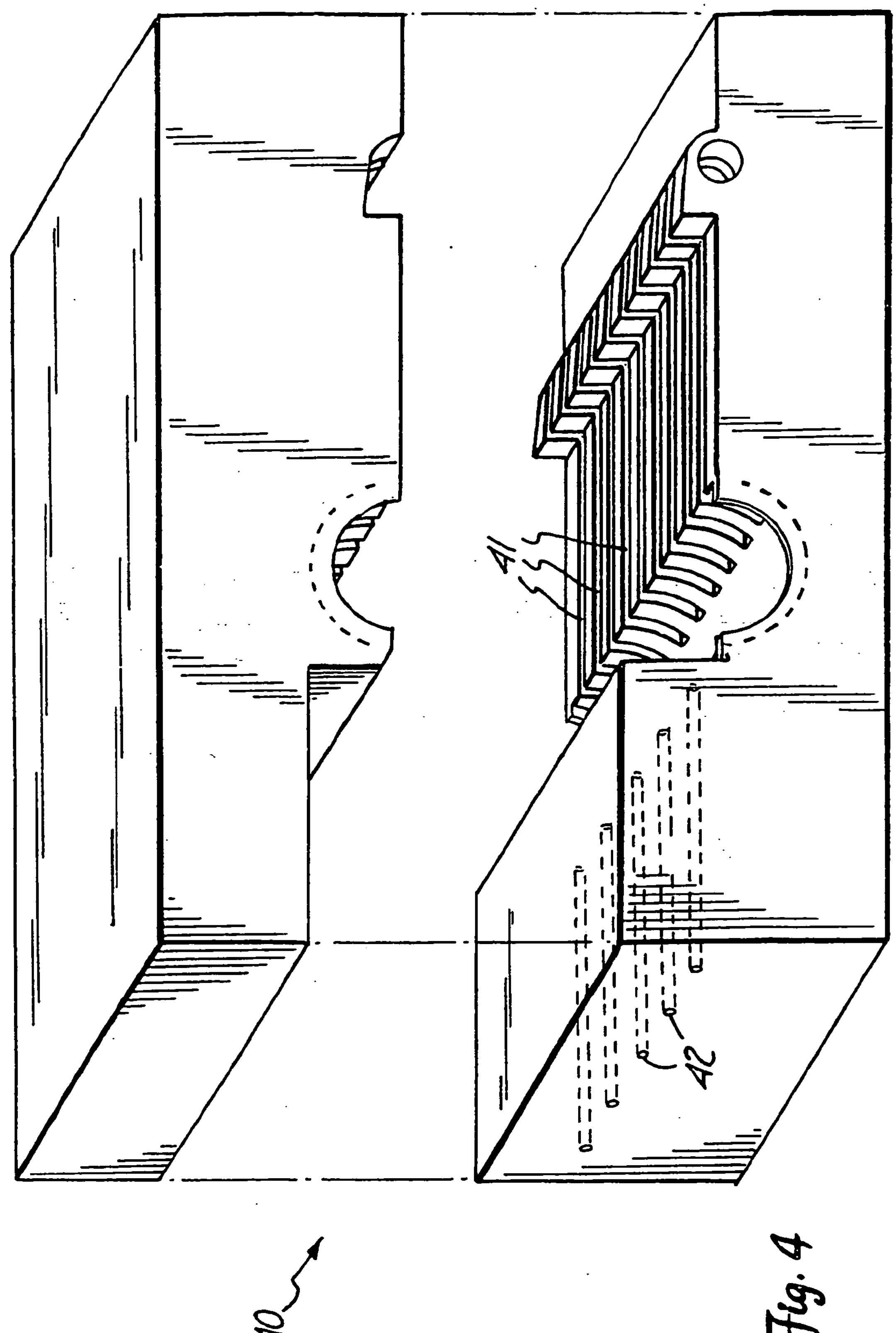

Fig. 4

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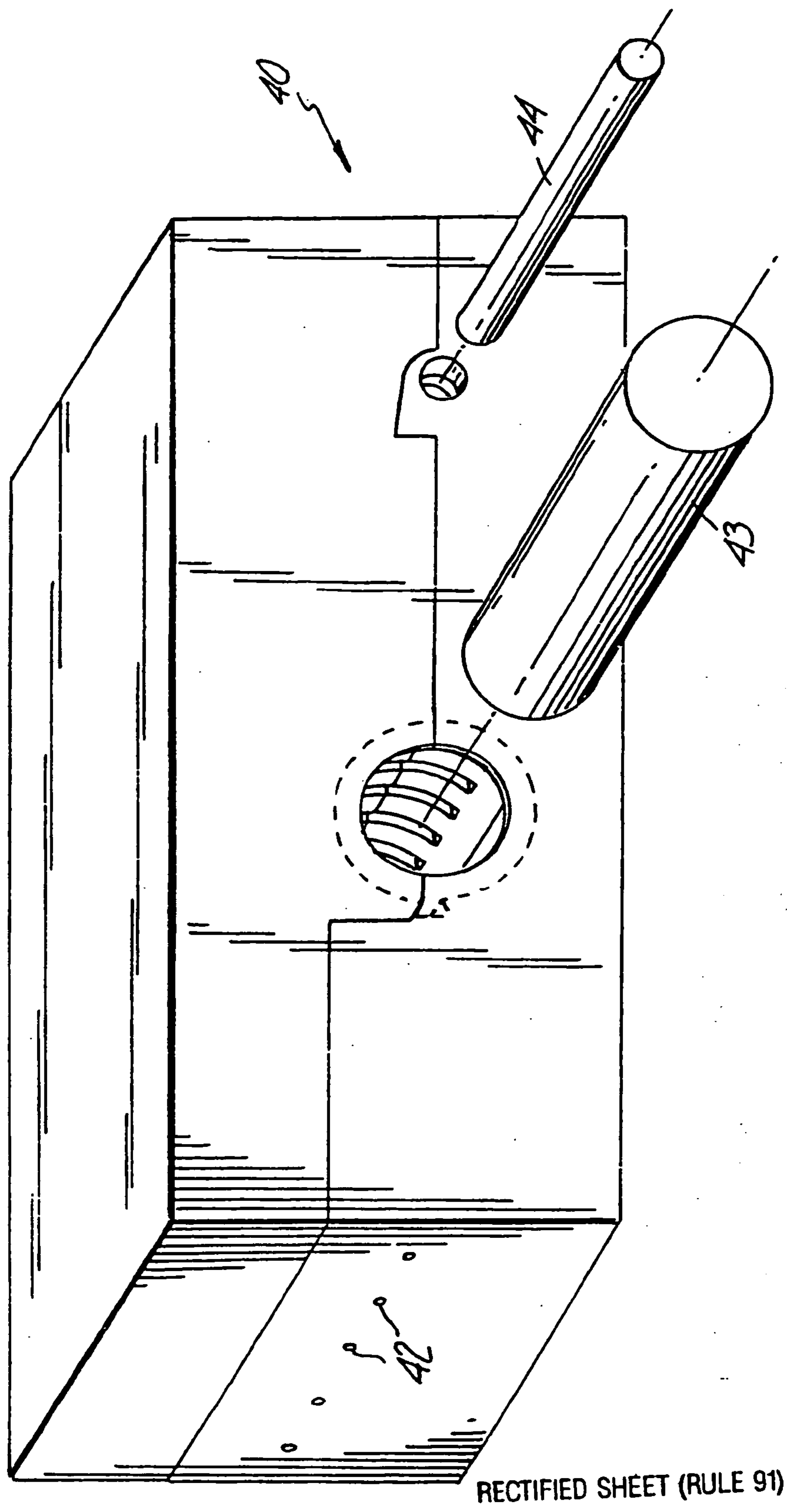

Fig. 5

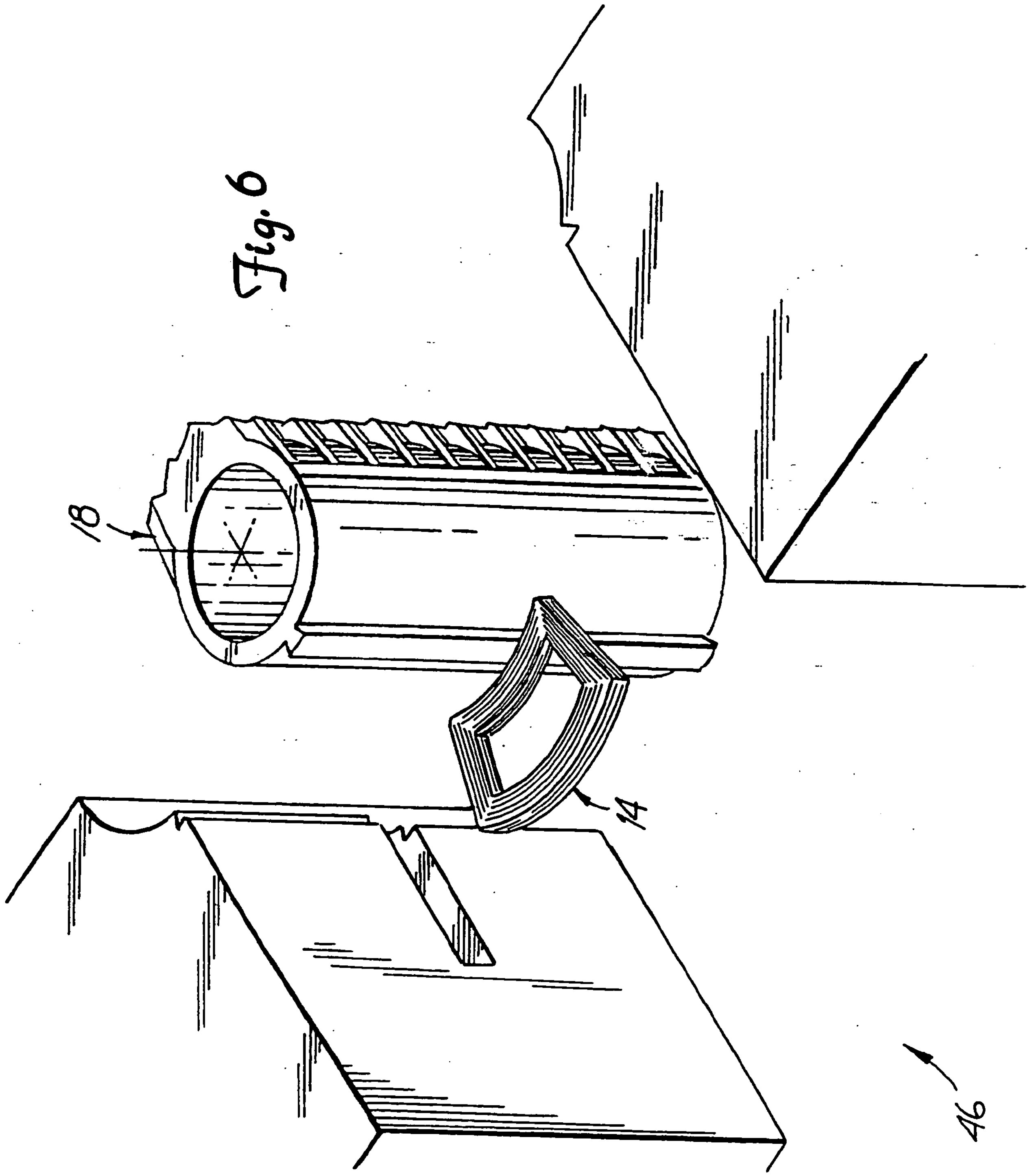

Fig. 6

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INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/00467

A. CLASSIFICATION OF SUBJECT MATTER

IPC(6) :G11B 5/55,21/08; B29C 45/03
US CL :360/106; 264/328.1
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 360/106,104,105; 264/328.1,328.7-328.19

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

APS (search terms: (disk or disc) (w) drive?, e-block, actuator?, injection (w) mold###, polymeric)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X --- Y	US,A, 5,168,185 (UMEHARA et al) 01 December 1992, figure 4,colunm 4 line 62 - column 7 line 11,column 8 line 63 - column 9 line 16.	1 ------- 2-10

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date		
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed	"&"	document member of the same patent family

Date of the actual completion of the international search 26 APRIL 1995	Date of mailing of the international search report 01 MAY 1995
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703) 305-3230	Authorized officer For R.S.TUPPER Telephone No. (703) 308-1601

Form PCT/ISA/210 (second sheet)(July 1992)★

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US95/00467

Box I Observations where certain claims were f und unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter n t required to be searched by this Auth rity, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

Please See Extra Sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☒ No protest accompanied the payment of additional search fees.

Form PCT/ISA/210 (continuation of first sheet(1))(July 1992)*

BOX II. OBSERVATIONS WHERE UNITY OF INVENTION WAS LACKING
This ISA found multiple inventions as follows:

This application contains the following inventi ns or groups of inventions which are not so linked as to form a single inventive concept under PCT Rule 13.1. In order for all inventions to be examined, the appropriate additional examination fees must be paid.

Group I, claim 1, drawn to an E-block structure .
Group II, claims 2-10, drawn to a method of injection molding.

The inventions listed as Groups I and II do not relate to a single inventive concept under PCT Rule 13.1 because, under PCT Rule 13.2, they lack the same or corresponding special technical features for the following reasons: the method of Group II merely sets forth a process for fabricating any structure with plural projecting arms and a coil. The resultant structure is not unique to a disk drive actuator.